Cutting Apparatus

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a cutting apparatus suited in cutting or half cutting a work-piece such as a ceramics package, a laminated board of a ceramic green sheet, a film material other than ceramics, a ceramic capacitor, a flexible board, a plastic sheet, and the like.

DESCRIPTION OF THE RELATED ART

There are various cutting apparatuses, which are commonly equipped with cutting blades, for example, for cutting or half cutting of a work-piece while moving the cutting apparatus per se or a table mounted with the work-piece, or for cutting or half cutting of the work-piece mounted on an index table while feeding the cutting apparatus per se by a fixed amount.

In case of an index table, the cutting apparatus executes cutting or half cutting of the work-piece while feeding the cutting apparatus per se by a fixed amount at respective time of turning the index table by an angle 90 degrees.

In case of half cutting of a laminated board of ceramic green sheet or the like before sintering into a shape of lattice pattern or the like, the cutting apparatus is composed of a column provided with a driving source and capable of controlling to move a cutting blade in a vertical direction to thereby move by a prescribed amount and the index table mounted with the work-piece on its surface. A driving source composed of a servomotor is driven at respective time of moving the column by a prescribed pitch in a longitudinal direction. After half cutting of the work-piece mounted on the surface of the index table in a shape of a strip which leaving a peripheral fringe portion thereof, the index table is turned by an angle of 90 degrees. Similarly at respective time of moving the column by a prescribed pitch in a longitudinal direction, the drive source is driven, the work-piece on the surface of the index table is similarly subjected to half cutting on a surface and a rear face of the work-pieces, and rectangular tips are obtained by cracking the board after sintering. The reason of half cutting of the board while leaving the peripheral fringe portion is that marks for cutting are provided on the peripheral fringe portion, the marks remain in the product (chip in rectangular

shape) obtained by sintering.

However, when cutting the laminated board of the ceramic green sheet or the like before sintering into a shape of lattice pattern or the like, the above described process is executed only from a surface side of the work-piece.

Meanwhile, there are various sorts in the work-piece in cutting or half cutting, for example, the ceramics package, the laminated board of ceramic green sheet, the film material other than ceramics, the ceramics capacitor, the flexible board, the plastic sheet, a product chip portion, or the like is included, besides, in cutting or half cutting, in a relationship between a knife edge of a cutting blade and a table surface a parallelism is required. Normally, the surface of the index table is constituted of a slanted flat surface inclined in one direction.

When the parallelism is not realized, perfect cutting can not be conducted, edge breakage is caused by colliding the cutting blade with the table, for example, depths of the half cutting from the surface side and rear face become non-uniform.

Particularly, for example, in the laminated board of the ceramic green sheet before sintering or the like, when

the depth of the half cutting is non-uniform, in cracking after sintering a crack, tipping, exfoliation of layer, or the like occur, in a laminated board having a recess portion of a SAW filter or the like on a surface side. When half cutting is executed from a position in proximity to the recess portion where a joining area between layers is small, the crack is easily produced at a peripheral wall part of the recessed portion due to dispersion force produced in cracking, a problem of remarkably causing the exfoliation of layer occurs.

Conventionally, as a method of realizing the parallelism, since the parallelism is produced by utilizing jack bolts as mounting members of the index table to the bed, gradually jacking up the index table by the jack bolts, while measuring a plurality of points between the knife edge of the cutting blade and the table surface formed of the slant flat surface inclined in one direction by micrometer, and therefore, assembling work of the index table to the bed is remarkably complicated, thus, a long period of assembling time is required.

SUMMARY OF THE INVENTION

In view of the forgoing conventional situation, the present invention has been carried out, it is an object of the present invention to provide the cutting apparatus of cutting or half cutting of the work-piece by producing the parallelism in executing cutting even when the parallelism is not yet realized between knife edge of the cutting blade and the surface of the table.

Another object of the present invention is to provide the cutting apparatus enabling to perform cutting or half cutting depending upon property of the work-piece.

Technical means devised to achieve the object described above is to constitute the cutting apparatus such that a column is provided with a support having the cutting blade, the support is constituted such that a tilting angle of the cutting blade in a blade length direction is capable of controlling, and the cutting blade is vertically movable relative to the support with the driving source provided on the support (first aspect).

Here, the blade length direction of the cutting blade is a (L) direction, and refer to (Fig. 2), (Fig. 5), (Fig. 9), (Fig. 10), (Fig. 14), and (Fig. 16). The (L) direction is referred to as an X-axial direction, and a direction

orthogonal to the (L) direction is referred to as an Y-axial direction.

The support is tilted in the blade length direction of the cutting blade so as to be turned into right angle to the table surface (table surface or surface of index table) constituting a slant flat face inclined in one direction. Whereby, a parallel relationship can be realized between the table surface mounting the work-piece and the knife edge.

Further, when a parallelism with high precision is required between the table surface and the knife edge of the cutting blade, the cutting blade is lowered to be brought into line contact with the table surface, a image of a state thereof is taken, the pick-up image is binarized or multi-valued by an image processing apparatus, a fine control amount is calculated based on the data, and means capable of controlling a tilting angle of the cutting blade in the blade length direction in the support is controlled.

Further, according to first aspect, a plurality of sorts of cutting blade units different in sorts of driving sources are constituted by utilizing the cutting blade, the support supporting the cutting blade, and the drive source provided on the support. The cutting blade unit is provided

replaceably on the column, and respective cutting blade unit may be constituted to be capable of controlling tilting angle of the cutting blade in the blade length direction (second aspect).

The driving source is preferably to be one of sources selected from a servomotor (third aspect), a hydraulic servomotor (fourth aspect), a linear motor (fifth aspect), an air cylinder, and a cam (eighteenth aspect).

The second to fifth, and eighteenth aspects are for enabling to perform cutting or half cutting depending upon the quality of the work-piece.

Further, in a case where are cutter supporting portion (cutter ram) is coupled to a plunger of the air cylinder and vertically movable, the apparatus is suited to constant speed cutting, and is advantageous in reducing cost.

Further, when the cutter supporting portion (cutter ram) is made vertically movable by a ball screw in which a screw rod directly connected to the servomotor as the drive source is fitted, a control of a bottom dead center and the high load cutting can be executed. When the cutter supporting portion (cutter ram) is made vertically movable by driving force of the servomotor as a driving source via a boosted

hydraulic circuit, not only can control the bottom dead center, but also higher load cutting than the servomotor can be executed, and both are suited in half cutting of the work-piece.

Furthermore, when the cutter supporting portion (cutter ram) is made vertically movable by the linear motor as a driving source, though weak in the cutting force, it enables to execute high speed cutting, further, the bottom dead center and cutting speed can be adjusted with high precision, and a beautiful cutting face can be obtained.

Further, when the cutter supporting portion (cutter ram) is made vertically movable by a cam rotated by driving force of a motor, the apparatus has characteristics such that it is suited to repeating motion at a high speed and constant speed, even though load applied is lower than when the servomotor is utilized as a drive source and is advantageous in reducing cost.

Utilizing respective characteristics, respective cutting blade unit utilizing the air cylinder, the servomotor, the hydraulic servo motor, and the cam as a drive source for moving the cutting blade vertically, the apparatus can be selectively utilized in cutting or half cutting of the various

work-pieces.

When the air cylinder as the driving source is adopted, since a vertical reciprocating amount of its cutter supporting portion is constant (vertical moving amount), for half cutting of the work-piece, it is necessary for the air cylinder to apply separate drive for reciprocating motion of the cutting blade, with consideration that respect, the apparatus is suited for cutting of components such as chips, cutting of outer periphery and the like, or for rough cutting. Further, since the servomotor can control respective positions of the top dead center and bottom dead center of the cutter supporting portion, an amount of half cutting can optionally be set and the apparatus is suited in half cutting of the ceramics package and products of chips.

Further, since the hydraulic servomotor is capable of executing higher load cutting than the servomotor, it is preferable in half cutting of a film (made of plastic) except thick walled ceramics, the laminated board of ceramics green sheet, or the like.

Further, the linear motor is suited in cutting or in half cutting of the work-piece of low viscosity where cracks are caused on the cutting surface when cutting speed is low.

Further, in case of cam the vertical reciprocating amount (vertical moving amount) of the cutter supporting portion is constant, a half cutting amount cannot be controlled, however, the apparatus with cam is suited for cutting of the part such as the chip or cutting of outer peripheral portion of the work-piece.

Further, a sensing portion movable in the blade length direction of the lowering cutting blade and constituted such that a parallel shape to the surface of the index table in a direction orthogonal to the blade length direction, is mounted on the surface of the index table for cutting a work-piece by the cutting apparatus according to first aspect of the invention, the index table, the sensing portion, the driving source of the cutting blade, and means capable of controlling tilting angle of the support are respectively linked with the control portion,

the control portion may be constituted to arithmetically process and store a tilting angle data of the cutting blade in the blade length direction by detecting a plurality of points of the knife edge in the blade length direction of the cutting blade, lowering from an original point position (top dead center) by the sensing portion

mounted on the surface of the index table both before and after turning the index table by an angle of 90 degrees. The control portion may be constituted to also process arithmetically and store a parameter of a lowering amount data of the cutting blade in half cutting or cutting of the work-piece at respective time of moving the cutting blade by a prescribed pitch from a driving amount of the driving source of the cutting blade by detecting the knife edge by the sensing portion, by lowering the cutting blade from the original point position (top dead center), after moving the cutting blade a prescribed amount in a direction orthogonal to the blade length direction (sixth aspect).

Here, respective cutting blade, the driving source of the cutting blade, means to make controllable the tilting angle of the cutting blade, the sensing portion, and the index table are linked with the control portion and constitutes a full close circuit.

The sensing portion is a block body movable in parallel in the blade length direction of the cutting blade and mounted to be movable in a direction orthogonal to the blade length direction, a contact body which will be described later (eighth aspect) or an optical sensor (tenth aspect), in a case

of contact body, contact body is capable of controlling to move linearly in the blade length direction and has a top portion in parallel with the surface of the index table in a direction orthogonal to the blade length direction, in a case where the sensing portion is the optical sensor the optical sensor can be provided at inside of a movable body of the upward open type capable of controlling to move linearly in the blade length direction, the movable body is formed in a shape having an inner space of desired with size not interrupting moving of the cutting blade in a direction orthogonal to the blade length direction.

According to the technical means, the sensing portion is mounted on the index table both before and after turning the index table by an angle of 90 degrees, the cutting blade is lowered from the original point position (top dead center), the sensing portion (block body, contact body, or optical sensor) is moved in a blade length direction and the cutting blade is lowered from the original point position (top dead center), the cutting blade can be detectable in any position of the knife edge (contact with knife edge for block body and contact body, in case of the optical sensor by optical amount blocked by lower end of knife edge). Therefore, for example,

one end side in the blade length direction is detected by the sensing portion, the data is transmitted (output) to a center of the full close circuit, succeeding, the sensing portion, for example, is moved to correspond to other end side in the blade length direction and detecting the other end side and the data is transmitted (output) similarly to the control portion, a correction amount (deviated angle) of the knife edge in a relative parallelism between the knife edge of the cutting blade and the surface of the index table, that is, tilting angle data can be obtained by these both data. Meanwhile, above described detecting positions are not needed to be both end in the blade length direction, but utilizing desirable any two points is sufficient. At that time, the tilting angle data of the cutting blade may be obtained by trigonometric function by setting length of the cutting length in the blade length direction.

Next, moving the cutting blade by a prescribed amount in the longitudinal direction (Y-axial direction), lowering the cutting blade from the original point position (top dead center), and detecting with the block body, the contact body, and the optical sensor, as a parameter of the lowering amount of the cutting length in half cutting or cutting of the

work-piece by lowering the cutting blade from the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch is arithmetically processed from the driving amount of the driving source and stored in the control portion.

The control portion arithmetically processes the lowering amount data of the cutting blade from the parameter when half cutting or cutting of the work-piece is carried out by lowering the cutting blade from the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch.

The above described tilting angle data and lowering amount data are utilized as data to carry out half cutting or cutting of the work-piece mounted on the index table both before and after turning the index table by an angle of 90 degrees.

Meanwhile, according to sixth aspect, ···constituting in a parallel shape relative to the surface of the index table in a direction orthogonal to the blade length direction··· does not only mean that like the contact body as mentioned above the sensing portion has the top portion in parallel to the surface of the index table in a direction orthogonal to

the blade length direction or the sensing portion is constituted such that like the optical sensor the optical sensor is provided at inside of the movable body of the upward opening type which is capable of controlling to move linearly in the blade length direction and the movable body is formed in a shape having an inner space of desirable width size not interrupting moving the cutting blade in a direction orthogonal to the blade length direction, but means that in a case where like when the block body described above is utilized, the block member moves not only in the blade length direction but also moves prescribed amount in parallel to the direction orthogonal to the blade length direction.

Further, in the cutting apparatus according to first aspect of the invention, the sensing portion movable in the blade length direction of the lowering cutting blade is mounted on the surface of the index table for cutting of the work-piece, the respective index table, the sensing portion, the driving source of the cutting blade, and means capable of controlling the tilting angle of the support are linked with control portion,

the control portion arithmetically processes the tilting angle data of the cutting blade in the blade length

direction by detecting a plurality of the points of the knife edge in the blade length direction of the cutting blade lowering from the original point position (top dead center) with the sensing portion mounted on the surface of the index table both before and after turning the index table by an angle of 90 degrees, a parameter of the lowering amount data of the cutting blade in half cutting or cutting at respective time of moving the cutting blade by a prescribed pitch is arithmetically processed from the driving amount of the driving source when the cutting blade tilted following the tilting angle data is moved the prescribed amount in a direction orthogonal to the blade length direction of the cutting blade, lowering the cutting blade from the original point position (top dead center), the knife edge of the cutting blade is brought into line contact with the index table and is stored (seventh aspect).

According to seventh aspect of the invention, respective cutting blade, the drive source of the cutting blade, means enabling to control the tilting angle of the cutting blade, the sensing portion, and index table are linked with the control portion and constitutes a full closed circuit.

As the sensing portion in this case other than the block body moved in the blade length direction, the contact body (ninth aspect), and the optical sensor (eleventh aspect), a probe (twelfth aspect) for detecting a displaced amount by moving in the blade length direction and brought into contact with the knife edge can be utilized.

According to the above described technical means, the tilting angle data of both before and after turning the index table by an angle of 90 degrees is sensed by the sensing portion (block body, contact body, optical sensor, probe or the like). The parameter of the lowering amount of the cutting blade in half cutting or cutting of the work-piece by lowering the cutting blade form the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch is obtained by arithmetically processing the driving amount of the driving source when the knife edge of the cutting blade is made in parallel to the index table from the tilting angle data, progressing or regressing the cutting blade by a prescribed amount, and lowering so as the whole knife edge to be brought into line contact with the surface of the index table. The control portion arithmetically processes the lowering amount data of the cutting blade when

half cutting or cutting of the work-piece is carried out by lowering the cutting blade from the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch with the parameter.

The tilting angle data and the lowering amount data are utilized as data to carry out half cutting or cutting of the work-piece mounted on the index table before and after turning the index table by an angle of 90 degrees.

Further, it is more preferable that the index table has an extractable positioning means mounted with the sensing portion for respective position before and after turning the index table by an angle of 90 degrees (thirteenth and fourteenth aspects).

That is, the sensing portion is positioned on the surface of he index table with excellent precision before and after turning the index table by an angle of 90 degrees, and the positioning means are extracted in half cutting or cutting and does not constitute an obstacle in cutting.

Further, in the cutting apparatus according to first aspect of the invention, respective index table for cutting of the work-piece, the drive source of the cutting blade, means capable of controlling the tilting angle of the support

are linked with the control portion,

the control portion arithmetically processes the lowering amount of the cutting blade from the both original point position (top dead center) as the tilting angle data of the cutting blade in a blade length direction to the surface of the index table from the driving amount of the driving source both by lowering the cutting blade from the original point position (top dead center) in a state where respectively slanting cutting blade the same angle on one side in the blade length direction and on other side both before and after turning the index table by an angle of 90 degrees, the knife edge of one end side and the other end side of the cutting blade are brought into contact with the surface of the respective index table. The parameter of the lowering amount data of the cutting blade in half cutting or cutting at respective time of moving the cutting blade by a prescribed pitch may be arithmetically processed from the driving amount of the driving source when the cutting blade tilted according to the tilting angle data is moved a prescribed amount in a direction orthogonal to the blade length direction, lowering cutting blade from the original point position (top dead center), and the knife edge is brought into line contact with

the index table and stored (fifteenth aspect).

In this aspect, respective cutting blade, the driving source of the cutting blade, means enabling to control the tilting angle of the cutting blade, and the index table are linked with the control portion and constitute the full closed circuit.

According to the above described technical means, the control portion arithmetically processes the lowering amount of the cutting blade from the both original point position (top dead center) by respectively lowering the cutting blade from the original point position (top dead center) after tilting the cutting blade the same angle in both direction in the blade length direction by the driving amount of the driving source. Thus, the tilting angle data can be obtained and stored.

Further, the cutting blade tilted by the tilting angle data is moved in a longitudinal direction by a prescribed amount, similarly the cutting blade is lowered from the original point position (top dead center), knife edge is brought into line contact with the index table, and from the driving amount of the driving source as a parameter of the lowering amount of the cutting blade in half cutting or

cutting of the work-piece by lowering the cutting blade from the original point position (top dead center) and stored in the control portion. The control portion arithmetically processes as the lowering amount data of the cutting blade in cutting or half cutting of the work-piece by lowering the cutting blade from the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch with the parameter.

The above described tilting angle data and the lowering amount data are utilized as data to carry out half cutting or cutting of the work-piece mounted on the index table before turning the table by an angle of 90 degrees.

Further, after turning the index table by an angle of 90 degrees, similar operation is executed, and similar to the claim described above the tilting angle data and the lowering amount data obtained at that time is utilized as data to carry out cutting after turning the index table by an angle of 90 degrees.

Further, the sensing portion is utilized as means to sense the edge breakage or abrasion of the knife edge of the cutting blade during operation to carry out half cutting or cutting of the work-piece when the edge breakage or the

abrasion will amount to equal to or more than prescribed range, transmission means for transmitting information to an operator is highly desirable in that it enable to expedite a period of replacement of the cutting blade to the operator when it is linked with the control portion (sixteenth aspect and 17).

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view of a first aspect of the invention;

Fig. 2 is a sectional side view of a cutting apparatus of the first aspect of the invention;

Fig. 3 illustrates a second aspect of the invention showing a sectional side view illustrating a state of removing a cutting blade unit constituting a drive source thereof by a servo motor or a hydraulic servo motor from a column of a cutting apparatus;

Fig. 4 is a sectional side view of the cutting apparatus in a state use thereof;

Fig. 5 is a front view of the cutting apparatus in a state use thereof;

Fig. 6 illustrates a third aspect of the invention showing a sectional side view of a cutting apparatus having

a cutting blade unit utilizing a linear motor as a driving source;

Fig. 7 illustrates a fourth aspect of the invention showing a sectional side view of a cutting apparatus having a cutting blade unit utilizing an air cylinder as a driving source;

Fig. 8 illustrates a fifth aspect of the invention showing a sectional side view of a cutting apparatus having a cutting blade unit utilizing a cam as a driving source;

Fig. 9 illustrates a sixth aspect of the invention showing a perspective view of an essential portion illustrating a relationship among an index table, a sensing portion mounted on a surface of the index table, and a cutter ram having a cutting blade at a lower end thereof;

Fig. 10 is a front view, in a sixth aspect of the invention, illustrating an outline of a state of providing a correction amount (deviated angle) of a knife edge with respect to a relative parallelism between the knife edge of a cutting blade and a surface of an index table by detecting one end side and other end side in a blade length direction (X-axial direction) by a sensing portion, that is, a tilting angle data of the cutting blade and illustrating a deviation

in parallelism between the index table and the knife edge of the cutting blade by exaggeration;

Fig. 11 is a side view, in the sixth aspect of the invention, illustrating an outline of a state of providing respective data of a driving amount of a driving source from an original point position (top dead center) by detecting the cutting blade by the sensing portion after moving the cutting blade by a prescribed amount in a Y-axial direction, and lowering the cutter blade from the original point position (top dead center), as a parameter of a cutting blade lowering amount in half cutting or cutting a work-piece after moving the cutting blade by a prescribed pitch in the Y-axial direction, and lowering the cutting blade from the original point position (top dead center), and illustrating the deviation in parallelism between the index table and the knife edge of the cutting blade by exaggeration similar to Fig. 10;

Fig. 12 illustrates a seventh aspect of the invention showing a perspective view of a jig utilized;

Fig. 13 is an enlarged side view thereof;

Fig. 14 is a front view, in an eighth aspect of the invention, illustrating an outline of a state in which a correction amount (deviated angle) of a knife edge with

respect to a relative parallelism between the knife edge of a cutting blade and a surface of an index table by detecting one end side and other end side in a blade length direction (X-axial direction) by the jig, that is, illustrating a tilting angle data of the cutting blade and illustrating the deviation in parallelism between the index table and the knife edge of the cutting blade by exaggeration;

Fig. 15 is a side view, in the eighth aspect of the invention, illustrating outline of a state of providing respective data of a driving amount of a driving source from an original point position (top dead center) when a total length of the knife edge of the cutting blade is brought into line contact with the index table, by moving the cutting blade by a prescribed amount in the Y-axial direction, and lowering the cutter blade from the original point position (top dead center), as a parameter of a cutting blade lowering amount in half cutting or cutting a work-piece after moving the cutting blade by a prescribed pitch in the Y-axial direction, and lowering the cutting blade from the original point position (top dead center), and illustrating the deviation in parallelism between the index table and the knife edge of the cutting blade by exaggeration similar to Fig. 10;

Fig. 16 is a front view illustrating a ninth aspect of the invention, and illustrating an outline of a state of providing a tilting angle data, and illustrating the deviation in parallelism between the index table and the knife edge of the cutting blade by exaggeration; and

Fig. 17 is a side view, in the ninth aspect of the invention, illustrating outline of a state of providing respective data of a driving amount of a driving source from an original point position (top dead center) when a total length of a knife edge of a cutting blade is brought into line contact with an index table, by moving the cutting blade by a prescribed amount in a Y-axial direction, and lowering the cutter blade from the original point position (top dead center), as a parameter of a cutting blade lowering amount in half cutting or cutting a work-piece at respective time of moving the cutting blade by a prescribed pitch in a Y-axial direction, and lowering the cutting blade from the original point position (top dead center), and illustrating a deviation in parallelism between the index table and the knife edge of the cutting blade by exaggeration similar to Fig. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Next, the present invention will be explained.

Fig. 1 and Fig. 2 show a cutting apparatus of a first aspect of the invention provided with a support having a cutting blade on a column, the support being constituted such that a tilting angle in a blade length direction of the cutting blade is capable of controlling, and the cutting blade being vertically movable relative to the support by a driving source provided on the support, Fig. 3 - Fig. 5 show a cutting apparatus of the second aspect of the invention constituted such that a cutting blade, a support supporting the cutting blade and a drive source provided on the support are unitized to constitute a plurality of sorts of cutting blade units different in the sort of the drive source, the cutting blade unit is provided on the column replaceably, and a tilting angle in a blade length direction of the cutting blade of respective cutting blade unit is capable of controlling, Fig. 6, Fig. 7, and Fig. 8 show cutting apparatus of a third aspect of the invention, a fourth aspect of the invention, and a fifth aspect of the invention, Fig. 9 - Fig. 11 show a cutting apparatus of a six aspect of the invention utilizing a sensing portion, Fig. 12 and Fig. 13 show a cutting apparatus of a seventh aspect of the invention utilizing the other sensing

portion, Fig. 14 and Fig. 15 show a cutting apparatus of an eighth aspect of the invention utilizing still other sensing portion, Fig. 16 and Fig. 17 respectively show a cutting apparatus of a ninth aspect the invention not utilizing the sensing portion.

Firstly, a cutting apparatus of a first aspect of the invention illustrated in Fig. 1 and Fig. 2 will be explained, symbol A denotes the cutting apparatus, symbol T denotes an index table.

The cutting apparatus A is provided with a column A2 capable of controlling to move in a longitudinal direction, that is, in a direction close to or separate from the index table T by a ball screw mechanism 100 including a servomotor as a drive source M provided on an upper surface of a machine bed A1, a support A3 is mounted on the column A2 capable of controlling a tilting angle in a direction orthogonal to a longitudinal direction being a moving direction of the column 2, a cutter mechanism A4 is vertically movably provided at the support A3 as illustrated in Fig. 1 and Fig. 2.

The index table T is installed above an upper face part of the machine bed A1 in front of the cutter mechanism A4 as illustrated in Fig. 1, and vacuum holes (not illustrated) are

opened scatteringly for temporally tacking a work-piece (not illustrated) on a machining face of a surface of the index table T.

The column A2 displays a channel shape in plan-view forming both parallel plate portions A2 - 1 and A2 - 1 in shapes of substantially rectangular triangle, and a front plate portion A2 - 2 of the parallel plate portions A2 - 1 and A2 - 1 are constituted to be a support face of the support A3.

The support A3 displays an inverse L shape in side-view as illustrated, a vertical plate portion A3 - 1 thereof is in a state of being brought into face contact with the front plate portion A2 - 2 of the column A2 described above and a tilting angle of a cutting blade B in a blade length direction (X-axial direction) is constituted to be capable of controlling.

Means 1 to make the tilting angle controllable is constituted of a central axis 11 for rotation inserted over a part of a lower end side in a central portion of the vertical plate portion A3 - 1 of the support A3 and the front plate portion A2 - 2 of the column A2, a brake mechanism 21 provided at a position directly above a central axis 11 for rotation, and a tilting force application mechanism 31 applying tilting

force to the vertical plate portion A3 - 1.

A brake mechanism 21 has a role to maintain a tilting state and utilizes a hydraulic brake pressingly fix the support A3 to the front plate portion A2 - 2 of the column A2 with a head portion 21b - 1 by regressing an axial portion 21b - 2 of a clamping piston (head portion 21b - 1 brought into contact with surface of vertical plate portion A3 - 1 and axial portion 21b - 2 inserting through loose hole 21a) 21b, when needed, inserting through a loose hole 21a opened at the vertical plate portion A3 - 1 of the support A3 and the front plate portion A2 - 2.

A magnetic brake or the like may be acceptable in a brake mechanism 21.

The tilting force application mechanism 31 is constituted by a cam (servomotor is utilized as drive source) 31a pushingly moves one side fringe of the vertical plate portion A3 - 1 of the support A3 and a damping spring 31b provided at a part of the front plate portion A2 - 2 made proximate to the other end fringe of the vertical plate portion A3 - 1 and the support A 3 is tilted in a direction (X-axial direction) orthogonal to a blade length direction of the cutting blade B against the damping spring 31b

centering the central axis 11 for rotation depending upon a rotating amount of the cam 31a.

A tilting amount of the support A3 is tiltable in a range where a hole inner face of the loose hole 21a collides with the axial portion 21b - 2 of the clamping piston 21b.

A piezoelectric element or a ball screw mechanism may freely be utilized in place of the cam 31a.

Guide rails A4 - 1 and A4 - 1 are vertically provided in parallel with each other on a surface of the vertical plate portion A3 - 1 of the support A3, a cutter ram A4 - 3 mounted with a cutter holder A4 - 2 having the cutting blade B demountably at the lower portion is vertically movably engaged with the guide rails A4 - 1 and A4 - 1 in a vertical direction, and the cutter ram A4 - 3 is made vertically movable in the vertical direction by a ball screw mechanism 100 including a servomotor as a drive source M1 installed on a horizontal plate portion A3 - 2 constituting an upper end of the support A3, thus the cutter mechanism A4 is constituted.

According to the cutting apparatus A of the first aspect of the invention thus constituted, the support A3 provided with the cutter mechanism A4 including the servomotor as the drive source is demountably mounted on the column A2 capable

of controlling the tilting angle in the blade length direction (X-axial direction) of the cutting blade B.

Thereby, the index table T and a knife edge of the cutting blade B are brought into a parallel relationship, and cutting and half cutting of the work-piece can be executed.

Meanwhile, a symbol D denotes a control portion.

Next, a cutting apparatus of the second aspect of the invention illustrated in Fig. 3 - Fig. 5, cutting apparatus of the third aspect of the invention, the fourth aspect of the invention and the fifth aspect of the invention shown in Fig. 6, Fig. 7, and Fig. 8 will be explained in this order, in these inventions, a support A3 having a cutting blade B is unitized for respective drive source of a cutting blade B, and is replaceably mounted on a column A2.

A cutting blade unit 5 is provided with the support A3 supporting a servomotor as a drive source BM1, and a cutter mechanism A4 provided vertically movably to the support A3 as illustrated in fig. 3, similar to the first aspect of the invention illustrated in Fig. 1 and Fig. 2, is mounted demountably at the column A2 of the cutting apparatus A.

The support A3 is displayed as an inversed L letter shape, similar to the first aspect of the invention illustrated in

Fig. 1 and Fig. 2, a drive source BM1, that is, a servomotor is installed above a horizontal plate portion A3 - 2.

In the support A3, guide rails A4 - 1 and A4 - 1 are vertically provided in parallel with each other on a surface of a vertical plate portion A3 - 1 similar to the first aspect of the invention, a cutter ram A4 - 3 mounted with a cutter holder A4 - 2 demountably having the cutting blade B at a lower portion is engaged with the guide rails A4 - 1 and A4 - 1 vertically movably, the cutter ram A4 - 3 is vertically movable by threadedly fitted a screw rod coupled to a servomotor BM1 in a ball screw provided in the cutter ram A4 - 3, to thereby constitute a cutter mechanism A4.

The cutting apparatus A is constituted by providing the column A2 capable of controlling to move in a longitudinal direction (Y-axial direction) by a ball screw mechanism 100 including the servomotor provided above upper face of the machine bed A1 similar to the first aspect of the invention as the drive source M, and the column A2 is displayed as a channel shape in plan-view having both parallel plate portion A2 - 1 and A2 - 1 in a shape of substantially rectangular triangle.

Means 1 to make the tilting angle capable of controlling

in the blade length direction (X-axial direction), as illustrated in Fig. 3 - Fig. 5, is constituted of a medium plate 2 interposed between the vertical plate portion A3 - 1 of the support A3 and the front plate portion A2 - 2 of the column A2, the center axis 11 for rotation inserted over lower portion side of the medium plate 2 and the front plate portion A2 - 2, the brake mechanism 21 provided in a position directly above a center axis 11 for rotation and the tilting force application mechanism 31 for applying the tilting force to the medium plate 2, the support A3 is demountable by fastening to the medium plate 2 by screws 200 (bolts).

The brake mechanism 21 has the role to maintain the tilting state, and utilizes hydraulic brake pressingly fixing the medium plate 2 to the front plate portion A2 - 2 of the column A2 by the head portion 21b - 1 by making the shaft portion 21b - 2 of the clamping piston (provided with head portion 21b - 1 brought into contact with face of medium plate 2 and axial portion 21b - 2 inserted through loose hole 21a) 21b inserted through the loose hole 21a opened on the medium plate 2 and the front plate portion A2 - 2 to the column A2 side, when needed. The magnetic brake or the like may be acceptable as the brake mechanism 21 similar to the first

aspect of the invention.

According to the support A3, there is opened a containing hole 3 for containing the head portion 21b - 1 of the clamping piston 21b at a portion where the clamping piston 21b of the brake mechanism 21 corresponds in the vertical plate portion A3 - 1 of the support A3, there is opened fitting hole 4 for fitting a boss 12 projected from the medium plate 2 at a portion where the central axis 11 for rotation corresponds, in a state where the support A3 is brought into contact with the surface of the medium plate 2 frontward from the column A2 such that the head portion 21b - 1 of the clamping piston 21b is contained in the containing hole 3, and the boss 12 is fitted in the fitting hole 4, the support A3 is fastened by screws 200 (bolts).

The tilting force application mechanism 31, as illustrated in Fig. 3, is constituted, similar to the first aspect of the invention, of the cam (utilizing servomotor as drive source) 31a for pushingly moving one side fringe of the medium plate 2, and a damping spring 31b in proximity to the other end fringe of the medium plate 2, which respectively provided at right and left of the front plate portion A2 - 2 of the column A3. Depending upon a rotary amount of the

cam 31a, the cutting blade unit 5 which is fastened by screws 200 (bolts) together with the medium plate 2 is tilted in X-axial direction (blade length direction of cutting blade) in a range in which a hole inner face of the loose hole 21a is collided with the axial portion 21b - 2 of the clamping piston 21b by pushingly moving the medium plate against the damping spring 31b centering on the central axis 11 for rotation. Of course, similar to the first aspect of the invention, the piezoelectric element or the ball screw may freely be utilized in place of the cam.

After controlling a tilting angle of the knife edge in the X-axial direction (blade length direction of cutting blade) in a state of being parallel to the index table T by the rotation amount of the cam 31a of the tilting force application mechanism 31, the brake mechanism 21 is operated and together with the medium plate 2 mounted demountably with the support A3 controlled tilting angle of the cutting blade unit 5 is maintained.

In the cutting apparatus A of the second aspect of the invention thus constituted, the cutting blade unit 5 provided with the cutter mechanism A4 including the servomotor as the drive source BM1 is demountably mounted on the column A2

capable of controlling the titling angle of the cutting blade in the blade length direction (X-axial direction).

Thereby, index table T is made in parallel relationship with the knife edge of the cutting blade B, cutting or half cutting of the work-piece can be executed.

Next, the third aspect of the invention illustrated in Fig. 6 will be described, the third aspect of the invention shows the cutting apparatus A utilizing a cutting blade unit 5 including a linear motor as a drive source BM2.

The cutting blade unit 5 is provided with engaging portions 15 and 15 on a rear face of a vertical plate portion A4a - 3 of a cutter ram A4 - 3 displayed as an inversed L shape, a pair of guide rails 25a and 25a is projected in parallel at a guide plate 25 in parallel to a vertical plate portion A4a - 3 arranged rearward from the vertical plate portion A4a - 3, engaging portions 15 and 15 are engaged with the guide rails 25a and 25a vertically movably, coils 6 constituting one constituent of a linear motor BM2 are vertically provided between the engaging portions 15 and 15 of the rear face of the vertical plate portion A4a - 3, magnets 7 are vertically provided at the surface of the guide plate 25 with a clearance therebetween transversely between the guide rails 25a and 25a

opposed to the coils 6, and the guide plate 25 is fastened demountably to the medium plate 2 of the second aspect of the invention illustrated in Fig. 3 - Fig. 5 by the screws 200 (bolts).

According to the medium plate 2, similar to the second aspect of the invention illustrated in Fig. 3 - Fig. 5, the lower end side thereof is axially supported by the central axis 11 for rotation inserted through the front plate portion A2 - 2 of the column A2.

There is constituted the means 1 capable of controlling the tilting angle in the blade length direction (X-axial direction) by the brake mechanism 21 provided in a position right above the central axis 11 for rotation and the tilting angle application mechanism 31 for applying tilting force to the medium plate 2 similar to the second aspect of the invention illustrated in Fig. 3 - Fig. 5, therefore, portions similar to those are designated by the same symbols and a specific description thereof will be omitted. In this invention, a containing recessed portion 8 for containing the head portion 21b - 1 of the clamping piston 21b are recessedly provided having a clearance between the rear face of the guide plate 25 at a portion where the clamping piston 21b of the

brake mechanism 21 corresponds in the medium plate 2. In a state where the cutting blade unit 5 slanted such that the knife edge of the cutting blade in the X-axial direction (blade length direction of cutting blade) becomes in parallel to the index table T by the rotary amount of the cam 31a of the tilting force application mechanism 31, controlled titling angle can be maintained in a state where the knife edge of the cutting blade B is in parallel with the machining face of the index table T by pushingly fixing the medium plate 2 to the front plate portion A2 - 2 of the column A2 by the operating brake mechanism 21.

Further, the fourth aspect of the invention illustrated in Fig. 7 will be described, the fourth aspect of the invention illustrates the cutting apparatus A utilizing a cutting blade unit 5 including an air cylinder as a drive source BM3.

The cutting blade unit 5 is an example of making vertically movable the cutter ram A4 - 3 of the second aspect of the invention illustrated in Fig. 3 - Fig. 5 by an air cylinder BM3, the cutter ram A4 - 3 is projected with a coupling portion A4 - 4 for coupling a plunger BM3 - 1 of the air cylinder BM3, a stopper body S having a stopper portion S1 at a lower end thereof where the coupling portion A4 - 4 abuts for setting

the bottom dead center of the cutting blade B to a prescribed value hangs from the front end of the horizontal plate portion A3 - 2 of the support A3. The other specific constitution is similar to the fourth aspect of the invention. Therefore, portions similar to those are designated by the same symbols and a specific description thereof will be omitted. The means 1 capable of controlling the tilting angle of the cutting blade in the blade length direction (X-axial direction) is provided similar to the fourth aspect of the invention.

Further, the fifth aspect of the invention illustrated in Fig. 8 will be explained, the fifth aspect of the invention illustrates the cutting apparatus A utilizing the cutting blade unit 5 including a cam as a drive source BM4.

The cutting blade unit 5 is provided with a servomotor M on a lower face of the horizontal plate portion A3 - 2 of the support A3 in the second aspect of the invention illustrated in Fig. 3 - Fig. 5, and is constituted such that the cutter ram A4 - 3 is vertically moved by pushingly moving a push-moving portion A4 - 5 projected from the cutter ram A4 - 3 by a cam BM4 driven to rotate by the servomotor M against a tension spring 300 interposed over the horizontal plate portion A3 - 2. Other specific constitution is similar to

that of the second aspect of the invention illustrated in Fig. 3 - Fig. 5. And therefore, portions similar to those are designated by the same symbols and a specific description thereof will be omitted. Similarly there is provided the means 1 capable of controlling the titling angle of the cutting blade in the blade length direction (X-axial direction).

Further, regarding the aspect of the invention of the cutting apparatus utilizing the cutting blade unit including a hydraulic servomotor as a drive source, although not illustrated, except the respect constituted such that a cutter ram is vertically moved by an output of a boosting hydraulic circuit by synchronizing the boosting hydraulic circuit with a servomotor. There is constructed a constitution similar to the second aspect of the invention illustrated in Fig. 3 - Fig. 5.

Respective cutting blade units 5 illustrated in the second aspect of the invention, the third aspect of the invention, the fourth aspect of the invention, and the fifth aspect of the invention illustrated in Fig. 3 - 5, Fig. 6, Fig. 7 and Fig. 8 are fastened by the screws 200 (bolt) to the medium plate 2 in the cutting apparatus 5, and are

interchangeable thereamong.

Next, explaining the sixth aspect of the invention illustrated in Fig. 9 - Fig. 11, the sixth aspect of the invention shows the cutting apparatus A producing the parallelism between the index table T and the cutting blade B by utilizing a sensing portion 9.

Respective drawings of the sixth aspect of the invention illustrate not a total of cutting apparatus, but only a relationship between the cutting blade B and index table T.

The sensing portion 9 is a contact body movable in a blade length direction of the cutting blade B and a top portion constituted in a parallel to a surface of the index table T in a direction orthogonal to the blade length direction, and is provided in a jig 19.

The jig 19 is constituted such that a servomotor is installed to one end face side of an upper face support base 19a in an elongated shape constituting a rectangle shape in a vertical cross section a lower face of which is brought into face contact with the surface of the index table T and an upper face of which is formed in parallel to the lower face, and a mounting stand 19b provided to be capable of linearly

controlling to move on the support base 19a in the longitudinal direction by a ball screw mechanism 100 with a servomotor M as a drive source is provided on the other end side, and the sensing portion 9 is mounted on an upper face of the mounting stand 19b.

Although a linear movement distance controlling the mounting stand 19b is preferably a distance longer than the blade length of the cutting blade B as the best mode, a distance having shorter than the blade length will also be accepted.

The sensing portion 9 is formed substantially in a bullet shape in a vertical sectional view having a cross width size of the support base 19a as illustrated in the sixth aspect of the invention, the top portion is in parallel to the upper face of the support base 19a over the whole length in the length direction, in another words, is formed in parallel to the surface of the index table T composed of the slant flat face in a shape inclined in one direction.

Symbol 10 denotes a plurality of positioning means (positioning pins) for positioning the support base 19a in the blade length direction of the cutting blade B by being brought into contact with side faces of the support base 19a. The positioning pins position the jig 19 mounted on the

surface of the index table T directed in the blade length direction of the cutting blade B before or after turning the index table by an angle of 90 degrees, and can be extracted, when not needed. Symbol 10a denotes an inserting hole thereof.

Respective cutting blade B, the drive source for vertically moving the cutting blade B (driving source electronically controllable such as servomotor, hydraulic servomotor, and linear motor) M1, BM1, BM2, the brake mechanism (hydraulic circuit) 21, the driving source M of the cam 31a of the means 1 to make the tilting angle of the cutting blade controllable, the jig 19 including the contact body 9, and the index table T are electrically linked with the control portion D and constitute the full closed circuit.

The control portion D includes an operation portion arithmetically processes tilting angle data of the cutting blade in the blade length direction by detecting a plurality of points of the knife edge in the blade length direction of the cutting blade B lowering from the original point position (top dead center) by the sensing portion (contact body) 9 mounted on the surface of the index table T both before and after turning the index table T by an angle of 90 degrees.

The operation portion arithmetically processes a parameter of lowering amount data of the cutting blade in half cutting or cutting at respective time of moving the cutting blade by a prescribed pitch from the driving amount of the driving source (driving source electrically controllable such as servomotor, hydraulic servomotor, and linear motor) M1, BM1, and BM2 by detecting the knife edge in lowering the cutting blade from the original point position (top dead center) after having moved the cutting blade B by a prescribed amount in a direction orthogonal to the blade length direction of the cutting blade by the sensing portion (contact body) 9 and a storing portion for storing the tilting angle data, and the parameter.

The parameter is a coefficient of gradient (ratio of gradient between prescribed moving distance and lowering amount up to bottom dead center) of the surface of the index table T obtained from the driving amount of the driving source (driving source electrically controllable such as servomotor, hydraulic servomotor, and linear motor) M1, BM1, and BM2 when the knife edge is detected by lowering the cutting blade B from the original point position (top dead center) after moving the cutting blade B by a prescribed amount in a

direction orthogonal to the blade length direction by the sensing portion (contact body) 9.

For example, as when the cutting blade B is moved by 5cm from the fixed point, the cutting blade is lowered from the original point position (top dead center) and detection is executed by the sensing portion (contact body) 9 and the lowering amount from the original point position (top dead center) is obtained as 10.1cm, and a lowering amount from the original point position (top dead center) is 10cm at the fixed point (before moving cutting blade) for lowering the cutting blade B the original point position (top dead center) detected by the sensing portion (contact body) 9,the coefficient of gradient is calculated as 0.1cm/5cm.

A procedure of calculating a parallelism between the cutting blade B and the index table T in a cutting apparatus A of the six the aspect of the invention thus constituted will be described.

Firstly, positioning means (positioning pin) 10 are brought into contact with side faces of the support base 19a to position and a jig 19 is mounted on the surface of the index table T.

The jig 19 becomes in parallel to the blade direction

(X-axial direction) of the cutting blade B by a positioning function of the positioning means 10, when the cutting blade B is moved directly above the jig 19, the sensing portion (contact body) 9 is brought into a plan-view mode directed in a direction (Y-axial direction) orthogonal to the blade length direction of the cutting blade B.

Further, the sensing portion (contact body) 9 is, for example, moved to be positioned directly below one end side in the blade length direction, in that state, the cutting blade B is lowered from the original point position (top dead center) and the knife edge is brought into contact with the top portion of the sensing portion (contact body) 9, and detects the driving amount of the driving source M1, BM1, and BM2 from the original point position (top dead center) until the knife edge is brought into contact with the sensing portion (contact body) 9, the data is transmitted (output) to the control portion D, succeedingly, the knife edge lowering from the original point position (top dead center) is brought into contact with the top portion of the sensing portion (contact body) 9 which is capable of controlling to move to correspond to the other end side in a blade length direction, and detects the lowering amount, and similarly,

transmits (outputs) data of the drive amount of the driving source M1, BM1, and BM2 to the control section D (refer to Fig. 11).

The control section D arithmetically processes (first tilting angle data) a correction amount (deviated angle) to the relative magnitude of parallelism between the knife edge of the cutting blade B and the index table T by both of the data and stores the data to RAM.

Next, the cutting blade B is moved by a prescribed amount in a direction orthogonal to the blade length direction, that is, in Y-axial direction, the cutting blade B is lowered from the original point position (top dead center) and brought into contact with the top portion of the sensing portion (contact body) 9, and a lowering amount (driving amount of driving source M1, BM1, and BM2) from the original point position (top dead center) is transmitted (output) to the control portion D (refer to Fig. 11).

The control portion D arithmetically processes the parameter (coefficient of gradient) from the data and operates the lowering amount data (first lowering amount data) in half cutting or cutting of the work piece (not illustrated) at respective time of moving the cutting blade

by a prescribed pitch in Y-axial direction based on the parameter (coefficient of gradient) and stores the data in RAM.

Above described process is operated similarly even when the index table T is turned by an angle of 90 degrees and the second tilting angle data and second lowering amount data are stored in the control section (RAM).

When half cutting or cutting is carried out, the control portion D controls the cam 31a based on the first tilting angle data tilts the support A3 or the cutting blade unit 5 in a blade length direction (X-axial direction) such that the knife edge of the cutting blade B is in parallel with the surface of the index table T, the brake mechanism 21 is controlled, and the tilting angle thereof is maintained.

Further, at respective time of moving the support A3 and the cutting blade unit 5 by a prescribed pitch in Y-axial direction, height data from the top portion of the sensing portion (contact body) 9 to the half cut position of the work-piece (not illustrated) mounted on the index table T is added to the first lowering amount data, the cutting blade B is lowered from the original point position (top dead center), and the work-piece is cut in half cutting. Of course

when cutting is applied instead of half cutting, the height data from the top portion of the sensing portion (contact body) 9 to the surface of the index table T is added and cutting is carried out.

When half cutting or cutting is carried out after turning the index table by an angle of 90 degrees, the height data from the top portion of the sensing portion (contact body) 9 up to the half cut position of the work-piece mounted on the surface of the index table T is added to the second lowering amount data and half cutting is carried out, when cutting is carried out instead of half cutting, height data from the top portion of the contact body up to the index table T is added to the second lowering amount data and cutting is carried out.

In half cutting, turning the work-piece (not illustrated) over, the process is repeated similar to the above described.

Next, the seventh aspect of the invention illustrated in Fig. 12 and Fig. 13 will be explained, and in the seventh aspect of the invention the sensing portion 9 is constituted by an optical sensor for detecting the position of the knife edge of the cutting blade B.

In the seventh aspect of the invention, the sensing portion 9 and the jig 19 are illustrated.

The sensing portion (optical sensor) 9 is provided at inside of a movable body 29 formed in an upward opening type (upwardly directed channel shape), the movable body 29 includes an inner space 29a of desired width size not interrupting movement of the knife edge in a direction orthogonal to the blade length direction, the movable body 29 in place of the mounting stand 19b is capable of controlling to move linearly on the upper face of the support base 19a by the ball screw mechanism 100 including the servomotor as a drive source M, and to thereby constitute the jig 19.

The sensing portion (optical sensor) 9 is arranged along one inner side face of the inner space 29a of the movable body 29, a light emitting element 9a is provided opposedly to the sensing portion (optical sensor) 9 on the other inner side face of the inner space 29a of the movable body 29, detects the photo amount not blocked by the knife edge of the cutting blade B, and transmits (output) data to the control portion D.

Further, width size of the inner space 29a is utilized as a space for moving the cutting blade B when the cutting

blade is moved in the Y-axial direction by a prescribed amount, at respective time of lowering the cutting blade B from the original point position (top dead center), and when the lowering amount from the original point position (top dead center) is transmitted (output) to the control portion D.

In the seventh aspect of the invention, a procedure to produce the parallelism between the cutting blade B and the index table T in the cutting apparatus A will be explained.

Since the procedure is similar to that of the sixth aspect of the invention except that whereas the detection is carried out by contact to the contact body constituting the sensing portion 9 in the sixth aspect of the invention, detection is carried out by a change in the optical amount, and therefore an explanation thereof will be omitted.

Further, the eighth aspect of the invention illustrated in Fig. 14 and Fig. 15 will be explained, in the eighth aspect of the invention, a block body mounted on the index table T directly is utilized as the sensing portion 9 and produces the parallelism between the cutting blade B and the index table T.

In the eighth aspect of the invention, only a relationship between the cutting blade and the index table

is illustrated.

In this invention, a position of the sensing portion (block body) 9, a bottom face thereof being a seating face on the surface of the index table T, can be changed by a plurality of positioning means (positioning pins) 10 on the surface of the index table T to be able to be positioned at both end portions of the knife edge portion of the cutting blade B in respective states before and after turning the index table by an angle of 90 degrees, similar to the sixth aspect of the invention and the seventh aspect of the invention.

Further, in a state where the sensing portion (block body) 9 is positioned on one end side of the blade length direction (X-axial direction), the cutting blade B is lowered from the original point position (top dead center), and the knife edge thereof is brought into contact with the top portion of the sensing portion (block body) 9, data of the driving amount of the driving source M1, BM1, and BM2 for bringing the knife edge from the original point position (top dead center) into contact with the sensing portion (block body) is transmitted (output) to the control portion D. Succeedingly, in a state where the sensing portion (block

body) 9 is positioned to corresponds to the other end side in the blade length direction (X-axial direction), lowering the cutting blade is lowered from the original point position (top dead center), similarly, knife edge is brought into contact with the top of the sensing portion (block body) 9, similarly, data of the driving amount of the driving source M1, BM1, and BM2 is transmitted (output) to the control portion D (Fig. 14).

The control portion D arithmetically processes the correction amount (deviated angle) to the relative parallelism between the knife edge of the cutting blade B and the index table T by utilizing both data (first tilting angle data before turning the index table T by an angle of 90 degrees and second tilting angle data after turning the table T by an angle of 90 degrees) similar to the seventh aspect of the invention, and the data is stored in the RAM.

Further, the sensing portion (block body) 9 is removed, a plurality of positioning means (positioning pins) 10 are extracted, the cutting blade B tilted according to the first tilting angle data and the second tilting angle data is moved in Y-axial direction by a prescribed amount, the cutting blade B is lowered to be brought into line contact with the surface

of the index table T, and the lowering amount from the original point position (top dead center) up to the bottom dead center (cutting blade is brought into face contact with surface of index table T) is operated with the driving amount of the driving source M1, BM1, and BM2 and similar to the above described the parameter is arithmetically processed and stored in the RAM (Fig. 15).

The control portion D arithmetically processes respectively the first lowering amount data and the second lowering amount data of the cutting blade.

When half cutting or cutting is carried out (when it is carried out before turning index table T by an angle of 90 degrees), the control portion D controls the cam 31a based on the first tilting angle data and tilts the support A3 and the cutting blade unit 5 in the blade length direction (X-axial direction) so as to be in parallel to the surface of the index table T, thereafter, the brake mechanism 21 is controlled and the tilting angle is maintained.

Further, at respective time of moving the support A3 or the cutting blade unit 5 by a prescribed pitch in Y-axial direction by the control portion D, half cut position of the work-piece mounted on the index table T is subtracted from

the first lowering amount data and half cutting of the work-piece is executed by lowering the cutting blade. Of course, in case of cutting instead of half cutting, the cutting is executed according to the lowering amount data.

When half cutting or cutting is carried out after turning the index table T by an angle of 90 degrees, by utilizing the second tilting angle data and second lowering amount data and the cutting is carried out similarly.

Next the ninth aspect of the invention obtaining the first and the second tilting angle data, the first and second lowering amount data without utilizing the sensing portion 9 will be described with reference to Fig. 16 and Fig. 17.

In this case, as illustrated in Fig. 16 in a state where the cutting blade B is tilted at same angle (for example 5 degree (refer to solid line and two dotted chain line)) in both directions of the blade length direction (X-axial direction), the both end portions of the knife edge of the cutting blade B are lowered from the original point position (top dead center), are brought into contact with the surface of the index table T, the control portion D arithmetically processes the lowering amounts from the both original point positions (top dead center) by the driving amount of the

driving source M1, BM1, and BM2, and to thereby provides the tilting angle data.

Further, the cutting blade B is tilted according to the tilting angle data, at respective time of moving the column A2 having the cutting blade B by a prescribed amount in Y-axial direction, similarly, the cutting blade B is lowered from the original point position (top dead center), the knife edge of the cutting blade B is brought into line contact with the index table, and as the parameter (coefficient of gradient) of the lowering amount of the cutting blade B in half cutting or cutting of the work-piece by lowering from the original point position (top dead center) and data is stored in the control portion (refer to Fig. 17).

The control section D arithmetically processes the data based on the parameter as a lowering amount data of the cutting blade in cutting or half cutting of the work-piece by lowering the cutting blade from the original point position (top dead center) at respective time of moving the cutting blade by a prescribed pitch in Y-axial direction.

In the index table T respective tilting angle data and the lowering amount data are obtained both before and after turning the index table T by an angle of 90 degrees.

When half cutting or cutting is carried out, since the procedure is similar to the sixth aspect of the invention, the seventh aspect of the invention and the eighth aspect of the invention, a specific explanation thereof will be omitted.

Meanwhile, as the sensing portion 9 of the sixth aspect of the invention illustrated in Fig. 9 - Fig. 11, the seventh aspect of the invention illustrated in Fig. 12 and Fig. 13, and the eighth aspect of the invention illustrated in Fig. 14 and Fig. 15, a probe for being brought into contact with the knife edge of the cutting blade B and detecting the displaced amount may be utilized.

In this invention, the probe being the sensing portion is capable of linearly controlling to move on the mounting stand, and the tilting angle data and lowering amount data are obtained similar to the method in the sixth aspect of the invention, the seventh aspect of the invention, and eighth aspect of the invention.

Further, the sensing portion 9 and the probe (sensing portion) utilized in the sixth aspect of the invention, seventh aspect of the invention, and eighth aspect of the invention, can be utilized as a sensing means of the edge

breakage of the knife edge of the cutting blade B during half cutting or cutting of the work-piece (particularly laminated board such as ceramic green sheet having electrode circuit).

In this case, the sensing portion 9 is positioned in the blade length direction (X-axial direction) of the cutting blade by the positioning means 10, while moving the sensing portion 9 linearly by a prescribed amount in the blade length direction (X-axial direction), the knife edge is sensed over its entire length by lowering the cutting blade from the original point position (top dead center), at that time, the control portion D is built in with a determining circuit for determining whether the edge breakage or abrasion is caused in the cutting blade incapacitance of use by comparing the reference data stored in the RAM of the control portion D and data of change in the driving amount of the driving source M1, BM1, and BM2, and to thereby enable to execute the determination.

Of course, a transmitting means E is linked to the control portion D, when the edge breakage or the abrasion is caused to be equal to or more than an allowable range, since yield of the product is lowered, the transmitting means E transmits the information to the operator.

The transmitting means is perfectly appeal to the visual sense or auditory sense of the operator such as alarming sound, a lamp, a buzzer and the like.

By the transmission, the cutting blade B is expected to exchange, and half cutting or cutting with excellent precision can be realized.

The edge breakage (including abrasion) is inspected periodically.

As the described above, the present invention proposes a convenient cutting apparatus such that the support having the cutting blade in the column is provided, the support is constituted to be capable of controlling the tilting angle in the blade length direction of the cutting blade, and since the cutting blade is vertically movable relative to the support by the drive source provided on the support, the work-piece can be cut by maintaining in parallel the knife edge of the cutting blade and the mounting surface of the work-piece (surface of table).

Moreover, according to second to fifth, and eighteenth aspects of the invention respectively different driving source such as a servomotor, an air cylinder, a linear motor, a hydraulic servomotor, a cam or the like and the cutting blade

vertically movable by receiving driving force of the driving source are provided and unitized, and selectively and replaceably mounted to the column, therefore, by effectively utilizing the characteristics of respective driving sources, the work-piece with low viscosity, high viscosity, high hardness, low hardness, fragile brittleness, or the like can be subjected to cutting or half cutting.

Accordingly, in carrying out cutting of the work-piece with no need of high precision cutting, cutting or half cutting of the work-piece with high hardness, cutting or half cutting of the work-piece of low viscosity, cutting of the work-piece of high viscosity, rough cutting suitable for various situation of the work-piece including half cutting of the work-piece, high precision cutting or high precision half cutting, the present invention provides the convenient cutting apparatus by selecting and replacing the cutting apparatus and carried out the cutting operation, therefore, edge breakage or cutting failure, moreover exfoliation of layers, crack or the like is prevented from occurring.

Particularly in a case where the servomotor, hydraulic servomotor, or linear motor as the drive source, when work-piece is cut at respective prescribed pitch while moving

the cutting blade by a prescribed pitch, the cutting blade can be controlled to a position of the bottom dead center which is coincident with the cutting depth gradually displaced at every cutting due to the slant of the mounting face, the cutting apparatus is particularly preferable in cutting or half cutting needing the high precision.

Besides, when the sensing portion is currently utilized as described in sixth aspect and seventh aspect of the invention, the parallelism between the index table and the cutting blade can be produced with high precision and the work-piece can be subjected to half cutting or cutting, and such a troublesome and complicated operation as obtaining the parallelism between the knife edge of the cutting blade and the surface of the table while manually jacking up gradually the index table by jack bolts and measuring a plurality of points by a micrometer is no more required.

Moreover, according to eighth to eleventh aspects of the invention, the sensing portion is provided with a contact body which is capable of controlling to move linearly in the blade length direction and having a top portion in parallel with the surface of the index table and directed in a direction orthogonal to the blade length direction, or an optical sensor

for detecting a position of the knife edge of the cutting blade, the optical sensor is provided at inside of the movable body of upward opening type which is capable of controlling to move linearly, and the movable body is constituted by including an inner space of desirable width size not interrupting movement of the cutting blade in a direction orthogonal to the blade length direction, thereby, execution data in half cutting or cutting of the work-piece can be obtained by only manual operation for positioning the sensing portion so as to be capable of controlling to move linearly along the blade length direction at respective time of turning the index table by an angle of 90 degrees, and operability is remarkably improved.

Further, according to thirteenth and fourteenth aspects of the invention, the sensing portion can be positioned at regular position and does not produce hindrance in cutting.

Further, according to fifteenth aspect of the invention, without utilizing the sensing portion, between the knife edge of the cutting blade and the mounting face (surface of index table) of the work-piece is made in parallel, and excellent precision cutting can be executed.

What's more, according to sixteenth and seventeenth aspects of the invention, the sensing portion can be utilized as a means for detecting the edge breakage of the knife edge of the cutting blade during half cutting or cutting of the work-piece, when the control portion determines the edge breakage or abrasion, the information is transmitted to the operator via the transmitting means and the replacement of the cutting blade can be expedited.

Having described specific preferred embodiments of the invention with reference to the accompanying drawings, it will be appreciated that the present invention is not limited to those precise embodiments, and that various changes and modifications can be effected therein by one of ordinary skill in the art without departing from the scope of the invention as defined by the appended claims.

The present disclosure relates to subject matter contained in priority Japanese Patent Application Nos. 2000-361561, filed on November 28, 2000, 2000-361562, filed on November 28, 2000, and 2001-327796, filed on October 25, 2001, the contents of all of which are herein expressly incorporated by reference in their entireties.